Light Pollution Research and Education at the LRC

Michele McColgan, Ph. D.

Yukio Akashi, Ph. D.

Lighting Research Center

Rensselaer Polytechnic Institute

April 8th, 2003

Lighting Research Center

Rensselaer

LRC's goals on light pollution

- Act as an independent third party facilitator for all stakeholders in outdoor lighting
  - Bridge the lighting, astronomical, and environmental communities
  - Provide a voice for outdoor lighting end-users
- Perform objective research to assist in lighting design, product specification, and regulation of efficient outdoor lighting

Research and education at the LRC

- Street lighting design patterns (CL&P)
- Lighting Answers on Light Pollution (NLPIP)
- Update parking lot luminaires (NLPIP)
- Luminaire Cutoff Classification and Skyglow (LRC)
- Luminaire design and development (NYSERDA, IDA, LRO)

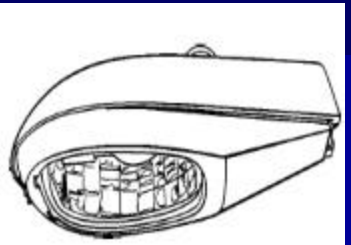
Street lighting design patterns (CL&P)

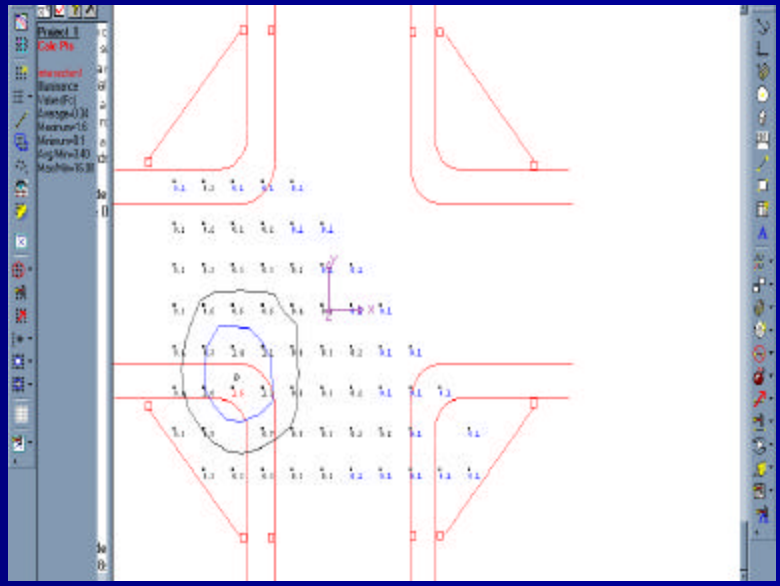
Street lighting design patterns (CL&P)

- White paper
- Checklist
- Street lighting design patterns
- March 12 seminar promoting the documents to Connecticut municipalities
- Available on the LRC website

Lighting design patterns for intersections

GE Full Cutoff
Cobra-head

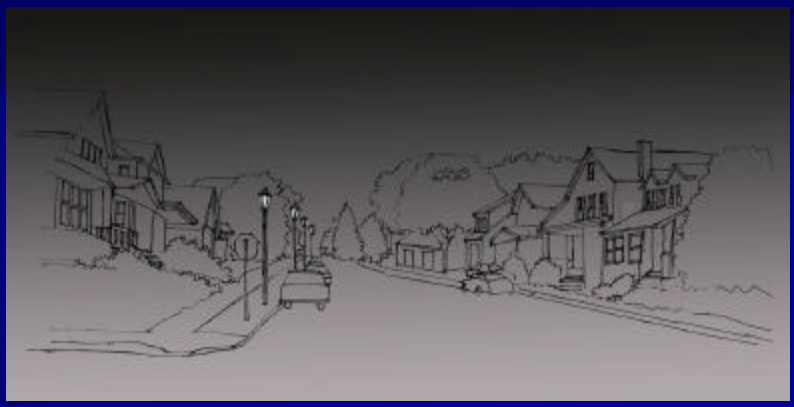


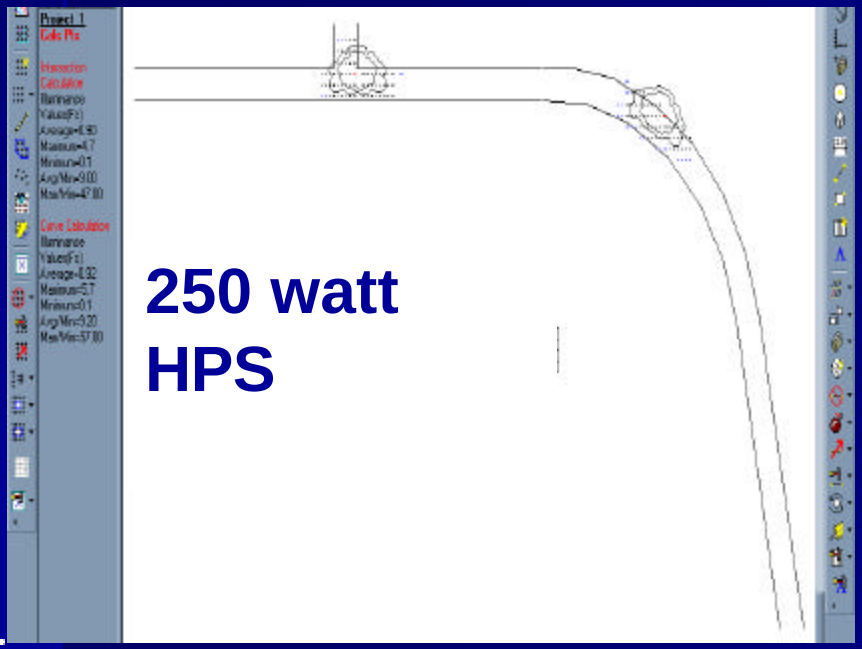


GE M250_FC_70WHPS_6300_27_1.60_3.40_16.00

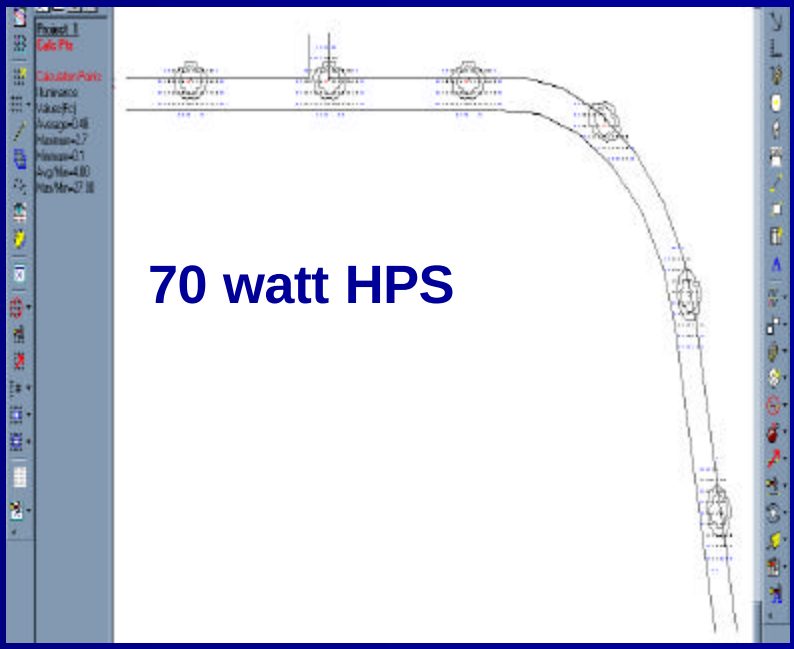
Lighting Design Patterns for Residential neighborhood with underground utilities

GE Salem





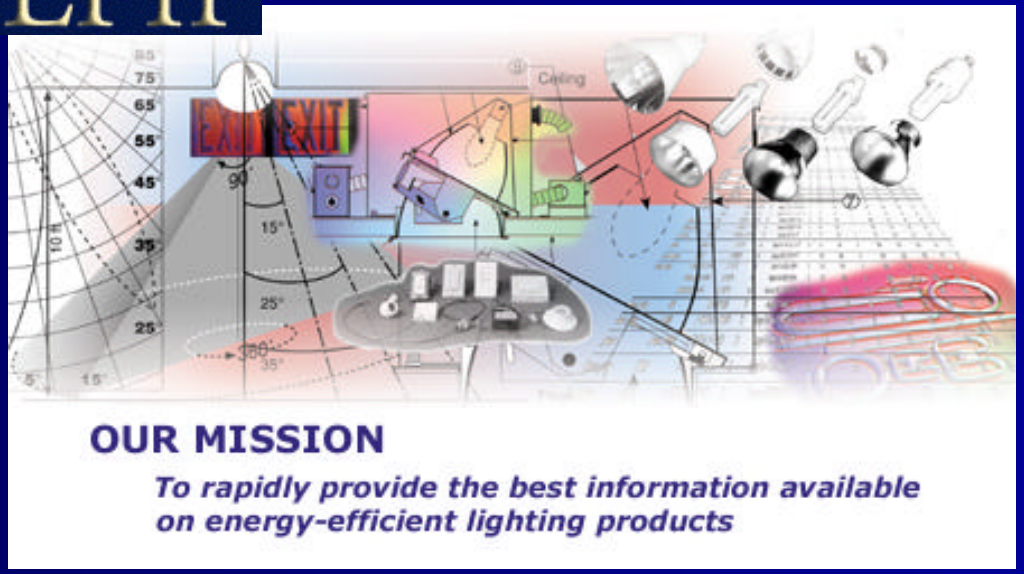
250 watt HPS



70 watt HPS

National Lighting Product Information Program (NLPIP)

NLPIP



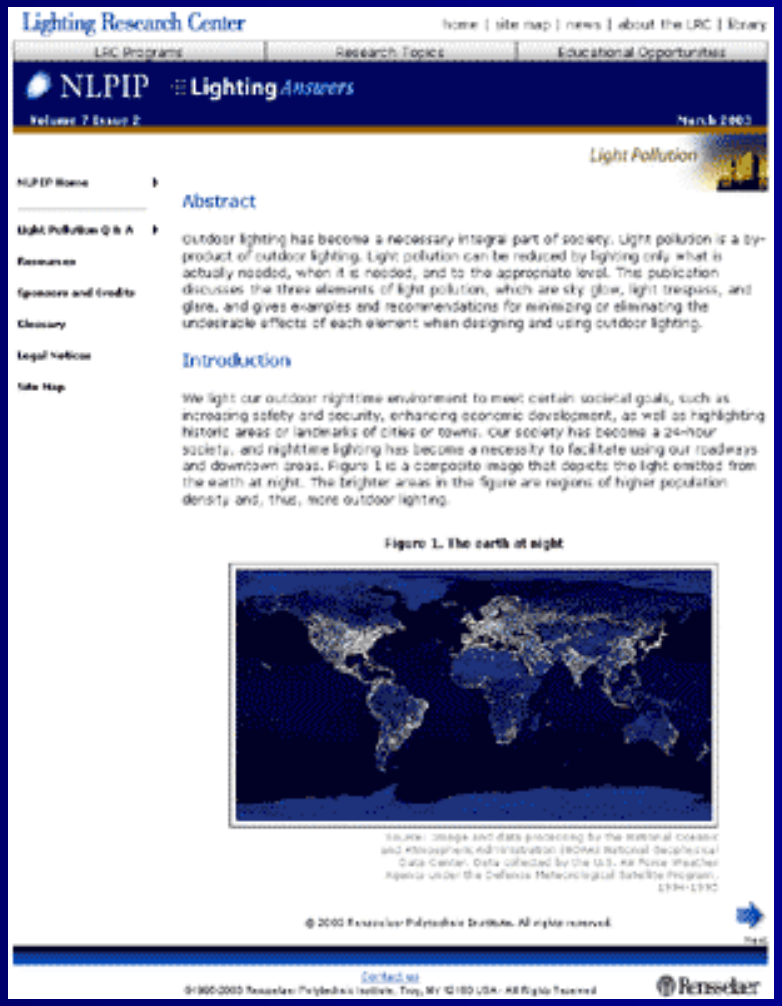
http://www.lrc.rpi.edu/nlpip/index.cfm

Lighting Answers on Light Pollution (NLPIP)

Lighting Answers on Light Pollution (NLPIP)

- On-line by March 15
- Questions and Answers Examples
  - What is light pollution?
  - What is sky glow?
  - What is light trespass?
  - What is glare?
  - How is the issue of light pollution currently being addressed?
  - What are lighting environmental zones?
  - How are luminaires evaluated for their potential to contribute to light pollution or light trespass?
  - What are the IESNA cutoff classifications?
  - Are the IESNA cutoff classifications a good indicator of direct uplight?
  - What is the difference between full cutoff and fully shielded?

Lighting Answers: Light Pollution onlined

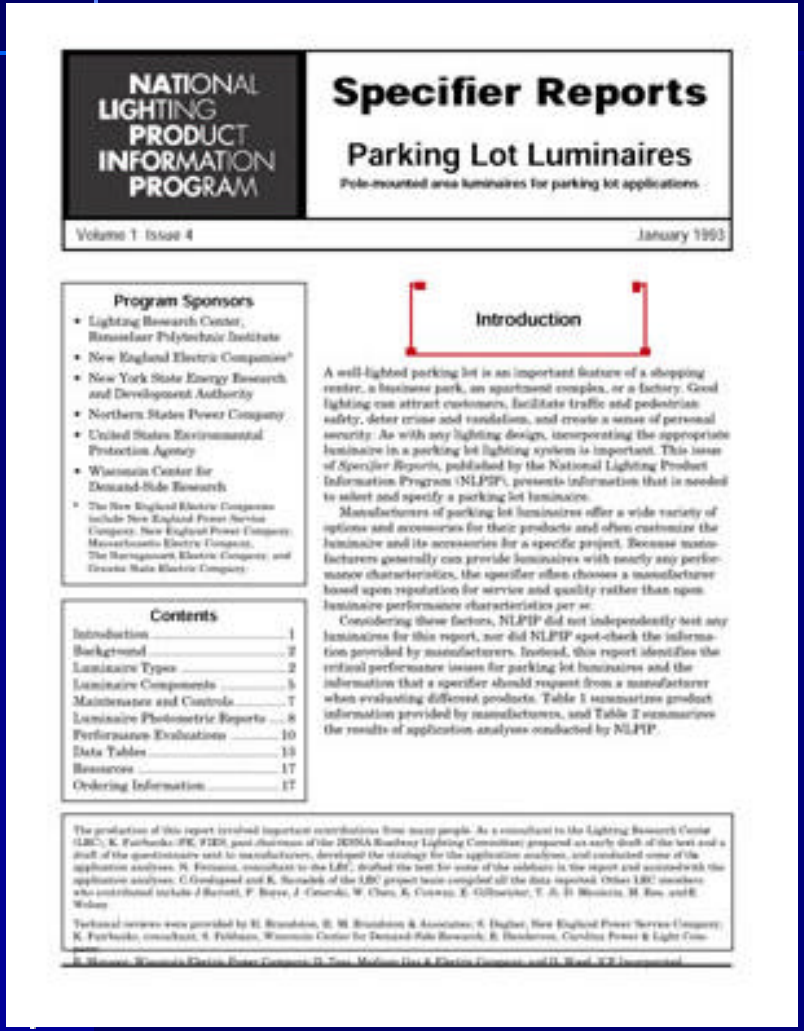


Lighting Research Center

Rensselaer

Update parking lot luminaires (NLPIP)

Update Specifier Report on Parking lot luminaires



NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports

Parking Lot Luminaires

Pole-mounted area luminaires for parking lot applications

Volume 1 Issue 4 — January 1993

Program Sponsors

- Lighting Research Center, Rensselaer Polytechnic Institute
- New England Electric Companies*
- New York State Energy Research and Development Authority
- Northern States Power Company
- United States Environmental Protection Agency
- Wisconsin Center for Demand-Side Research

* The New England Electric Companies include New England Power Service Company, New England Power Company, Massachusetts Electric Company, The Narragansett Electric Company, and Granite State Electric Company.

Contents

Introduction

A well-lighted parking lot is an important feature of a shopping center, a business park, an apartment complex, or a factory. Good lighting can attract customers, facilitate traffic and pedestrian safety, deter crime and vandalism, and create a sense of personal security. As with any lighting design, incorporating the appropriate luminaire in a parking lot lighting system is important. This issue of *Specifier Reports*, published by the National Lighting Product Information Program (NLPIP), presents information that is needed to select and specify a parking lot luminaire.

Manufacturers of parking lot luminaires offer a wide variety of options and accessories for their products and often customize the luminaire and its accessories for a specific project. Because manufacturers generally can provide luminaires with nearly any performance characteristics, the specifier often chooses a manufacturer based upon reputation for service and quality rather than upon luminaire performance characteristics *per se*.

Considering these factors, NLPIP did not independently test any luminaires for this report, nor did NLPIP spot-check the information provided by manufacturers. Instead, this report identifies the critical performance issues for parking lot luminaires and the information that a specifier should request from a manufacturer when evaluating different products. Table 1 summarizes product information provided by manufacturers, and Table 2 summarizes the results of application analyses conducted by NLPIP.

The production of this report involved important contributions from many people. As a consultant to the Lighting Research Center (LRC), K. Fairbanks (PE, FIES, past chairman of the IESNA Roadway Lighting Committee) prepared an early draft of the text and a draft of the questionnaire sent to manufacturers, developed the strategy for the application analyses, and conducted some of the application analyses. N. Ferrazza, consultant to the LRC, drafted the text for some of the sidebars in the report and assisted with the application analyses. C.Grodzicki and K. Sarnecki of the LRC project team compiled all the data reported. Other LRC members who contributed include J.Bartnett, P. Boyce, J. Cimerski, W. Chen, K. Conway, E. Gilbertson, T. Ji, D. Mosiewicz, M. Rea, and E. Wolsey.

Technical reviews were provided by H. Brandston, H. M. Brandston & Associates; S. Dagher, New England Power Service Company; K. Fairbanks, consultant; S. Feldmann, Wisconsin Center for Demand-Side Research; R. Henderson, Carolina Power & Light Company; R. Mosser, Wisconsin Electric Power Company; D. Tess, Madison Gas & Electric Company; and D. Ward, ICF Incorporated.

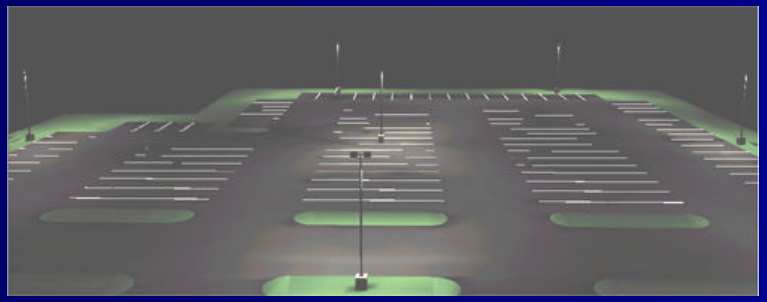
- Original published in 1993
- Has become outdated
  - No full cutoff classification
  - Not much consideration of light pollution concerns
  - More products currently available

Update Specifier Report: Goals

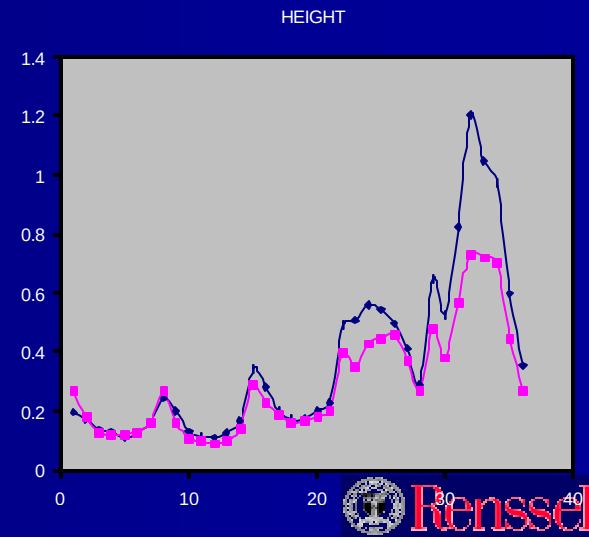
- Expand scope of the earlier report
  - Provide manufacturer's data
  - Examine energy efficiency
  - Explore light pollution issues
    - Uplight (reflected and direct), trespass, and glare
  - Include product testing
    - Full 360° intensity characterization, spot check manufacturers
  - Include further application analysis
    - % of lumens in the glare zone
    - % uplight lumens
    - Explore new classification system

Luminaire Cutoff Classification and Skyglow (LRC)

Luminaire Cutoff Classification and Skyglow



Blue -measured
Pink – Software



Objectives

- To study the effects of different types of cutoff luminaires on local skyglow
  - Explore design layouts for
    - Average illuminance values
    - Minimum illuminance and max/min ratio
    - Compliance with IESNA standards
- Develop simulation procedure: Lighting Metric
- Create skyglow mitigating fixture

Experimental Geometry

- Parking lot in Rensselaer Technology Park
- $R_{asphalt}$ = 7%
- Dimensions 135’ x 180’
- Grass surrounding parking lot extends 200’ in each direction
- 18 pole-mounted luminaires
  - 4 full cutoff, 7 cutoff, 7 semicutoff
  - from different manufacturers

Cutoff Classifications

Classification	Candelas at or above 90°	Candelas between 80° and 90°
Full Cutoff	0	<10%
Cutoff	<2.5%	<10%
Semicutoff	<5%	20%
Noncutoff	NA	NA

- % of luminous flux (in lumens)

Conditions

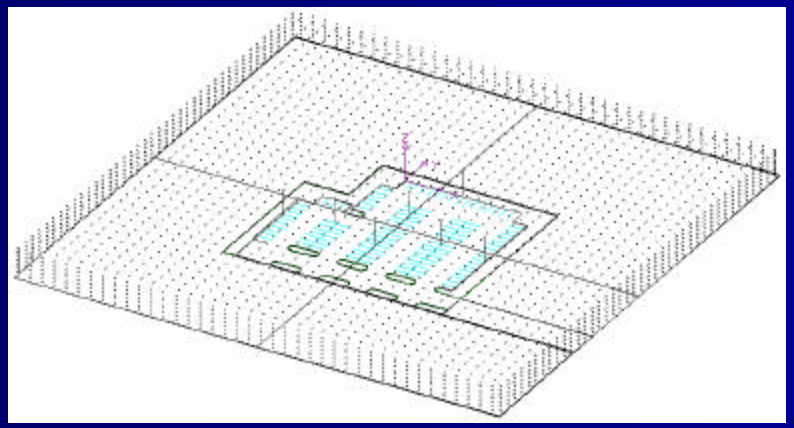
- Constants
  - height (30’), wattage (250W), and throw (Type-III)
- Similar average ground illuminance (~ 25 lux)
  - In all cases the IESNA parking lot recommendations of min illuminance > 2 lux and max/min ratio < 1:20 were met
- Variables
  - # luminaires
  - spacing

Light Pollution Index (LPI)

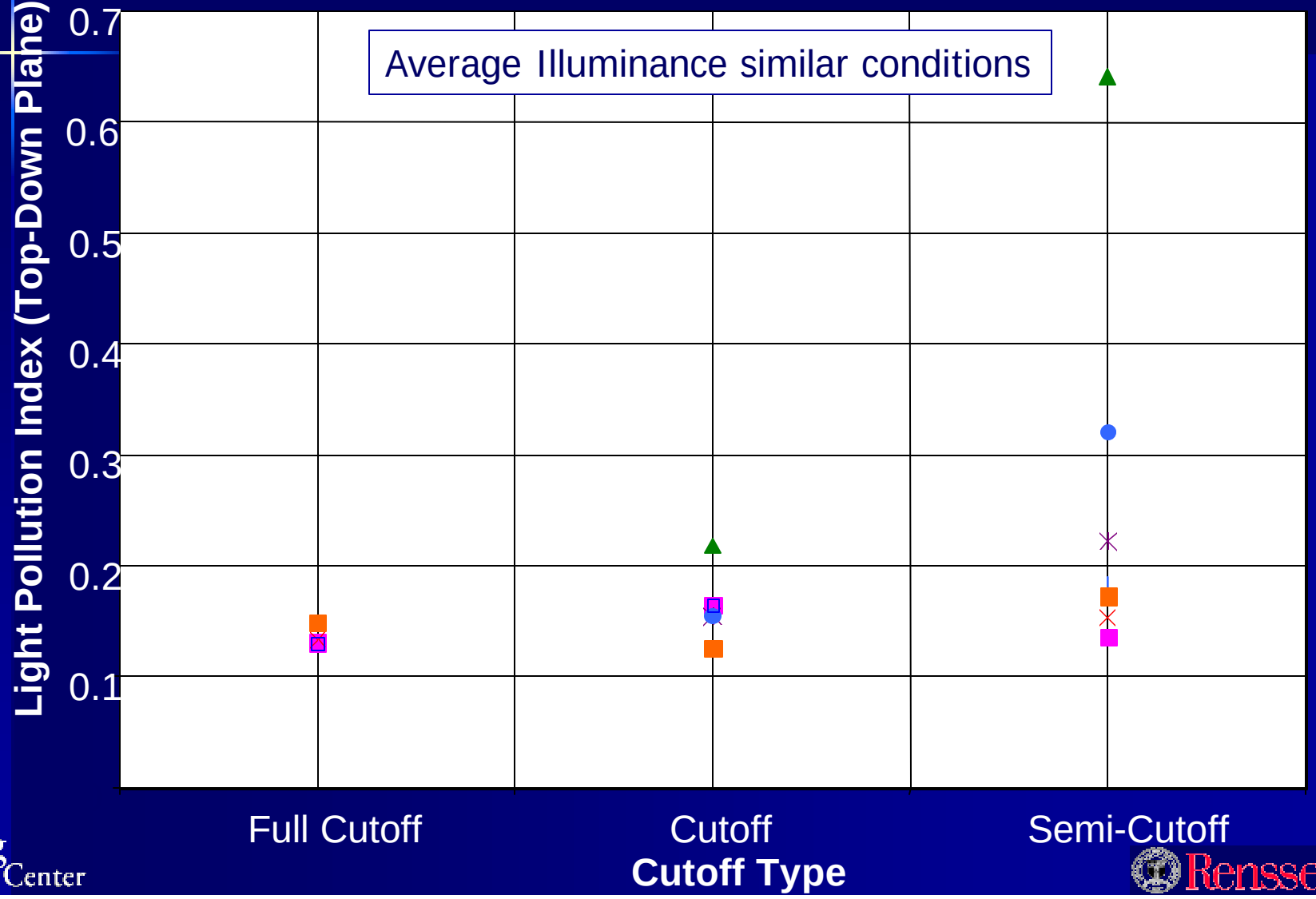
- "**Light pollution index**" or **LPI**
  - Ratio of the lumens on each plane to the lumens falling on the parking lot surface
- Total luminous flux (in lumens) on 5 virtual planes
- Pollutant lumens
  - Lumens falling on the top-down plane and on the top of the 4 vertical planes

Calculations for Light Pollution Index (LPI)

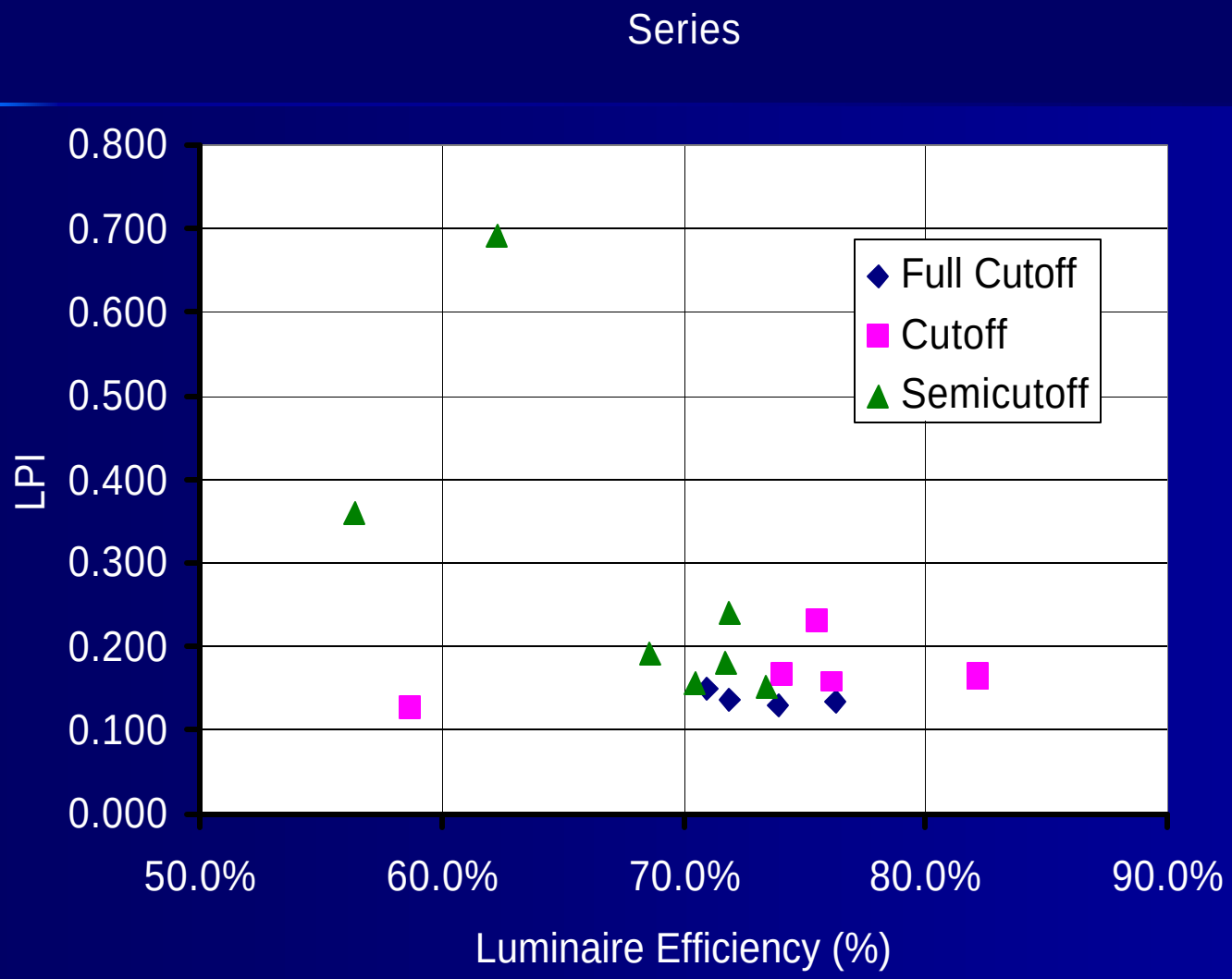
- 1 horizontal ceiling plane pointing downwards located 35’ above the ground (5’ above luminaires)
- 35’ tall vertical wall planes on each side of the lot
  - Located about 200’ away from the edge of the lot



LPI - Top-down plane



Analysis & Discussion of Results



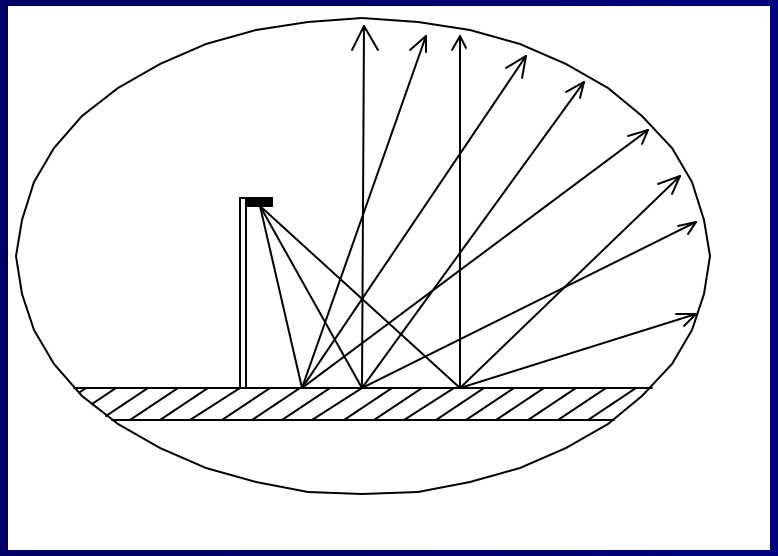
Cutoff Classification and Skyglow Conclusions

- Modeling methods can be used to predict and compare skyglow
- IESNA Cutoff classification is not:
  - A good predictor of # of lamps needed
  - A good predictor of total **system** uplight
- This work needs further exploration to determine **why** luminaires exhibit these features regardless of cutoff classification

Luminaire design and development (NYSERDA, IDA, LRO)

Luminaire design and fabrication

- Light Pollution luminaire development
- Sparkle luminaire
- Spectrum



Direct and reflected candela distribution

Conclusions

- Research is enabling outdoor lighting that is more *efficient* and *responsive*
  - How is the outdoor environment lighted using as little energy as possible but still achieving societal goals?
  - When do we light?
- Application of research findings is most efficient when the entire roadway system is considered

Thank you!

Luminaire Characteristics

Luminaire and Cutoff Type	Efficiency (%)	% Above 90°	% Between 80° and 90°
Manufacturer A			
Cutoff1	82.20%	1.10%	5.40%
Cutoff2	82.20%	1.10%	5.40%
Semicutoff1	68.60%	0.58%	14.33%
Semicutoff2	71.90%	1.47%	19.18%
Manufacturer B			
Fulll Cutoff1	76.30%	0.00%	2.00%
Fulll Cutoff2	71.00%	0.00%	4.50%
Cutoff1	82.20%	0.20%	5.80%
Cutoff2	58.70%	0.30%	6.16%
Semicutoff1	73.40%	3.32%	19.91%
Semicutoff2	71.70%	1.20%	15.60%
Manufacturer C			
Cutoff1	75.50%	1.43%	7.42%
Cutoff2	76.10%	0.24%	1.45%
Semicutoff1	62.30%	4.67%	8.92%
Semicutoff2	56.40%	3.14%	19.80%
Manufacturer D			
Full Cutoff1	71.90%	0.00%	2.95%
Full Cutoff2	73.90%	0.00%	1.67%
Cutoff	74.10%	0.09%	3.73%
Semicutoff	70.50%	0.02%	14.16%